Alberta's
ARCTIC GRAYLING
Management and Recovery Plan

Alberta
ENVIRONMENTAL PROTECTION
Natural Resources Service

ALBERTA'S

ARCTIC GRAYLING

MANAGEMENT AND RECOVERY PLAN

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April, 1998
Edmonton

Alberta Environmental Protection
Natural Resources Service
Fisheries Management Division

Pub. No.: T/ 410
ISBN: 0-7785-0149-3
Date: April, 1998

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PREFACE

The following document summarizes information on Arctic grayling in Alberta and outlines new management strategies that have been adopted. The document is presented in a nontechnical fashion to better serve as public information; however, considerable information was obtained from published papers and files. Readers are encouraged to review scientific literature on Arctic grayling. The following sources are of particular value: Armstrong (1982), Beauchamp (1982 & 1990), Bishop (1971), Carl et al (1992), Craig and Poulin (1975), Kratt and Smith (1977), Machniak and Bond (1979), McPhail and Lindsey (1970), Miller (1946), Northcote (1995), R.L.&L. Environmental Services Ltd. (1993a, 1995a & 1995b), Scott and Crossman (1973), Sterling and Hunt (1989) and Ward (1951).

Discussions on Arctic grayling management were included in the regulations review conducted by the Eastern Slopes Regulations Review Steering Committee during the spring and summer of 1997. Regulation options outlined in Alberta's Arctic Grayling Management and Recovery Plan, although broader in scope, are compatible with the recommendations of the steering committee.

Appreciation for their involvement is extended to staff of Alberta Natural Resources Service, in particular, Carl Hunt (retired), Dave Walty, Hugh Norris, Duane Radford, Jim Stelfox and Mike Sullivan. The Alberta Conservation Association (ACA) is gratefully acknowledged for its support of programs and studies which enhance fisheries management in Alberta. Trevor Thera of the ACA assisted with the summarization of Arctic grayling data for the Northwest Boreal Region. Laverne McAthey (ACA) and Natalie Cook (ACA) provided editorial services and helped in the final production of the document. Kerry Brewin, Jim O'Neil, Barry Mitchell, Tony Blake and Norm Rodseth commented on the plan on behalf of Trout Unlimited Canada. Brad Fenson, Ivan Johnston and Martin Paetz commented on the plan on behalf of the Alberta Fish And Game Association.

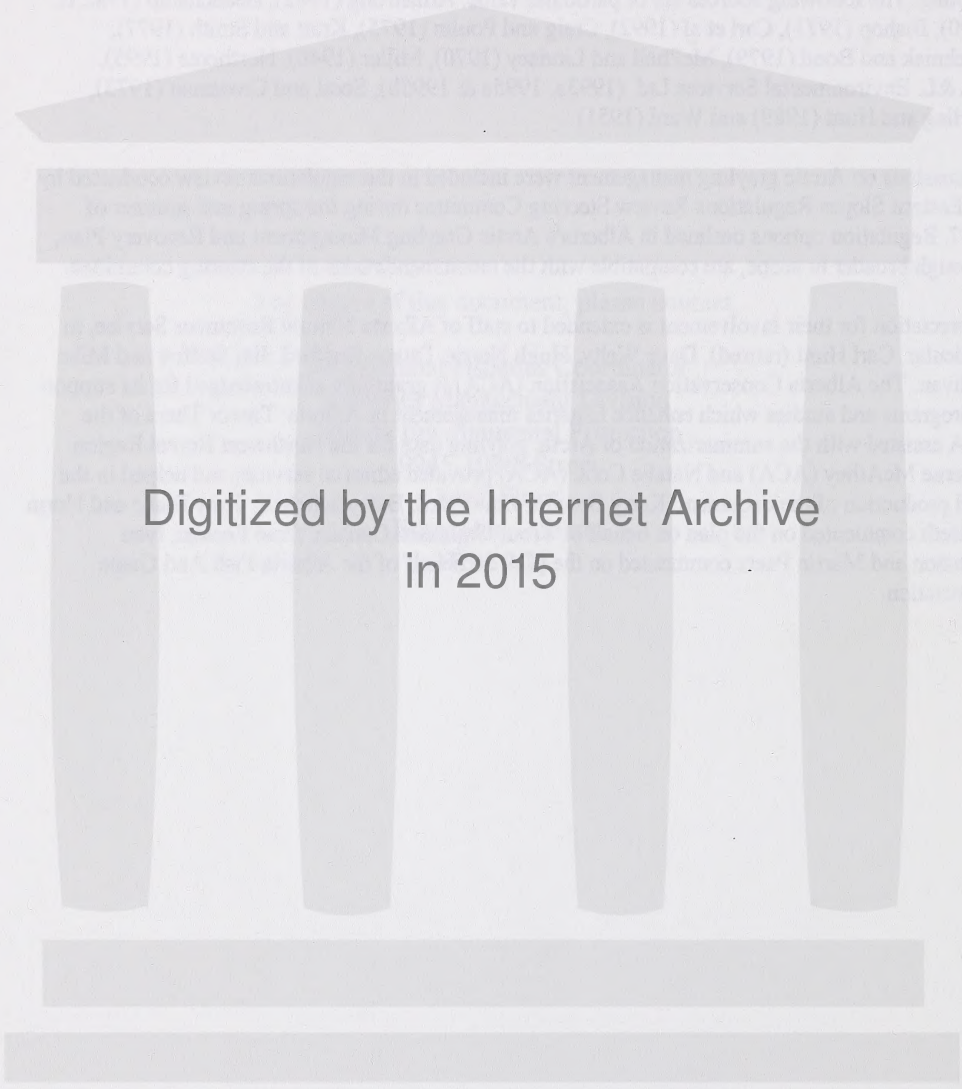

TABLE OF CONTENTS

LIST OF FIGURES

ABSTRACT

The Arctic grayling is truly Alberta's northern beauty, the "peacock" of the trout family, so thought of because of the male's iridescent colouration, flamboyant dorsal fin, and spawning-ground displays. "Uniquely attractive, beautiful to look at, sporting to catch, this species has declined significantly across its range because of its inability to cope well with man's encroachment" (McPhail and Lindsey 1970).

Arctic grayling are found in many streams across northern Alberta. Over the past four decades, increased development and improved access have contributed to population declines. Past regulations have not sustained Arctic grayling populations in Alberta. The minimum-size limit of 30 cm total length in effect from 1987 to 1998 did not prevent the harvest of immature Arctic grayling. Most Arctic grayling reach full maturity at four years of age and 33 cm total length. The daily catch limit of five Arctic grayling in effect from 1970 to 1998, coupled with increased fishing pressure, has resulted in overharvest. Catch rates for Arctic grayling have fallen well below 4-7 fish/hour, to less than 1 fish/hour at many stream, an indicator that Arctic grayling production is being limited by overharvest and habitat quality. Arctic grayling populations in Alberta are classified in a vulnerable status--a term used to describe the status of a species of special concern in need of conservation measures to reverse long-term declines.

Arctic grayling populations in the Northern East Slopes, Northwest Boreal and Northeast Boreal regions have similar patterns of growth, age-class distributions, age and size at maturity, catch rates and vulnerable status. Therefore, a single approach to the regulation of sportfishing for Arctic grayling can be applied throughout the species range in Alberta.

Alberta's Arctic Grayling Management and Recovery Plan is based on the mission statement, goals, objectives and guiding principles presented in the document *A Fish Conservation Strategy for Alberta* (Fisheries Management Division 1997). The overall goal for grayling management is:

> **"To sustain the abundance and diversity of natural reproducing Arctic grayling populations and provide recreational and economic benefits to Albertans."**

Habitat maintenance, fish conservation and fish-use allocation are three components of the above goal. They are expressed as follows:

Habitat Maintenance:

- Restore and maintain the natural productive capacity of Arctic grayling habitat, and where possible and appropriate, increase the amount of productive Arctic grayling habitat.

Fish Conservation:

- Restore and maintain the abundance, distribution and diversity of Arctic grayling populations through natural reproduction.

Fish-Use Allocation:

- Allocate the appropriate uses of Arctic grayling resources to achieve a range of optimal benefits that support the fish conservation goal.

Sportfishing is by far the largest use of the Arctic grayling resource in Alberta. Therefore, new sportfishing regulations have been implemented in 1998 as part of the plan to recovery and sustain Arctic grayling populations in Alberta.

As of 1998, the winter and spring sportfishing seasons will remain closed from November through May. The general season during which anglers are allowed to catch and keep Arctic grayling will be restricted to the summer (June, July and August), followed by catch-and-release fishing during a portion of the fall (September and October). The minimum-size limit will be increased from 30 cm to 35 cm total length. This change will protect at least three mature age classes (ages 3, 4 and 5) prior to grayling reaching the size for legal harvest. A decrease in the daily catch limit from 5 to 2 will be made to reduce harvest and to distribute the available harvest more fairly among anglers. Coupled with the larger minimum-size limit, the reduced daily limit and short harvest season will result in the availability of more spawners and will subsequently result in an increase in the production of young fish. Zero-limit fisheries (catch-and-release) will be established at various streams to permit faster recovery of collapsed populations, to sustain unique recreational opportunities through the provision of quality fisheries and quality fishing experiences, and to ensure the quality of the wilderness experience at "heritage" river systems.

Success of the new sportfishing regulations over the next 5 to 10 years will result in the following:

- An increase in the number of grayling that grow to maturity and spawn.
- An increase in the available number of spawners and subsequently an increase in the production of young fish.
- An increase in the protection provided to spawning grayling to ensure reduced disturbance during spawning.
- An increase in the number of larger grayling to provide recreational opportunities to catch large fish and to experience the true beauty of this unique species.
- An increase in catch rates to provide more satisfying recreational experiences.
- An increase in fish-viewing opportunities involving Arctic grayling.

The long-term success of Alberta's Arctic Grayling Management and Recovery Plan depends on the availability of good and timely information which is fundamental to achieving the habitat maintenance, fish conservation and fish-use allocation goals. Inventory, monitoring and research is required for:

- Gathering relevant information on fish stocks (including their number, growth, production rate, harvest rate and habitat conditions, and to assess the effectiveness of regulations and habitat protection, rehabilitation and enhancement).
- Identifying and recording the location of critical grayling habitat and migration routes requiring protection, rehabilitation and/or enhancement.
- Conducting studies to identify relationships between beavers and grayling habitat quality, and investigating beaver management solutions.
- Conducting specific studies of life history, including movements and critical habitat requirements.
- Determining the carrying capacity of various habitats for Arctic grayling, the conservation needs to perpetuate grayling populations and the numbers that constitute a harvestable surplus.
- Conducting studies to understand the interaction between land-use impacts and natural events that limit or enhance grayling populations.
- Investigating the use of gear restrictions such as bait bans, barbed hook bans and treble hook bans, for their potential to reduce hooking mortality.

The following document consists of an overview of Arctic grayling in Alberta and the management plan to provide continued public benefits through the conservation of the species. To maintain it as an evolving document, evaluations and updates of this management and recovery plan will occur as new information becomes available.

Arctic Grayling
Thymallus arcticus

1.0 SPECIES OVERVIEW

1.1 Classification and Description

Arctic grayling (*Thymallus arcticus*) is the only member of the grayling subfamily of the trout family found in Alberta. Other subfamilies of trout in Alberta are the trout subfamily (trout and char) and the whitefish subfamily (whitefish and cisco). Distinguishing characteristics of the Arctic grayling are the large dorsal fin and the small mouth with teeth in both jaws. Grayling have larger scales than trout and char, and are much more colourful than whitefish and cisco.

Colour can vary for grayling depending on where the fish live, their size and their maturity. Variations in colour make it hard to give a general description for this species. A bronzy or greyish look tends to dominate the colouration of most grayling in Alberta which are small, immature fish. Very young grayling have irregular rows of dark spots or broken lines above 10-20 dark brown parr marks along their sides. The adults are the most colourful.

Large grayling, over 40 cm in length, can have a spectacular mauve or bluish iridescent look. The darker colouration along the back extends onto the head, and blends down the sides to a lighter colouration of a greenish-grey or occasionally bluish-grey. Their bellies are grey to white with a dusky, golden or dark stripe between the paired fins. Black spots occur on the anterior portion of their sides. Grayling have colourful dorsal and pelvic fins. The dorsal fin is black with a mauve, red or orange outer edge above a blue band and vertical rows of orange or mauve to emerald green spots. The pelvic fins are dark and have wavy mauve or orange lines. Mature males can be distinguished from mature females by their more intensive colouration, especially during the spawning period, by their distinctly larger dorsal fin which extends back to or beyond the adipose fin, and by their larger pelvic fins.

The common misuse of the name "grayling" for mountain whitefish frequently results in anglers confusing mountain whitefish with Arctic grayling. Mountain whitefish have a much smaller dorsal fin with no coloured bands or spots, and they do not have black spots along their silvery sides. A taxonomic history of the Arctic grayling and a key to species of the trout family can be found in *The Fishes of Alberta* (Nelson and Paetz 1992).

1.2 Distribution and Status

1.2.1 Distribution

Arctic grayling are typically found in northern drainages entering the Arctic Ocean, the Bering Sea and the northern portion of the Pacific Ocean, in both Eurasia and North America. In Canada, populations of grayling also occur in a few drainages on the northwest shores of Hudson Bay. Scattered, fragmented populations of Arctic grayling can be found in Montana in the headwaters of the Missouri River.

Arctic grayling are native to the Athabasca, Peace and Hay river drainages in Alberta (Figure 1). Although the Pembina River is the southern limit of viable, self-reproducing populations in Alberta, grayling have on rare occasions been taken from the Belly River in southern Alberta. In the late 1980s, Arctic grayling were stocked into a few mountain lakes in southwestern Alberta; however, none have survived more than 9 years because of winterkill conditions. Arctic grayling were reintroduced into some of these lakes in 1997. Other than these minor exceptions, Arctic grayling are absent from the North Saskatchewan, Red Deer, Bow and Oldman drainages.

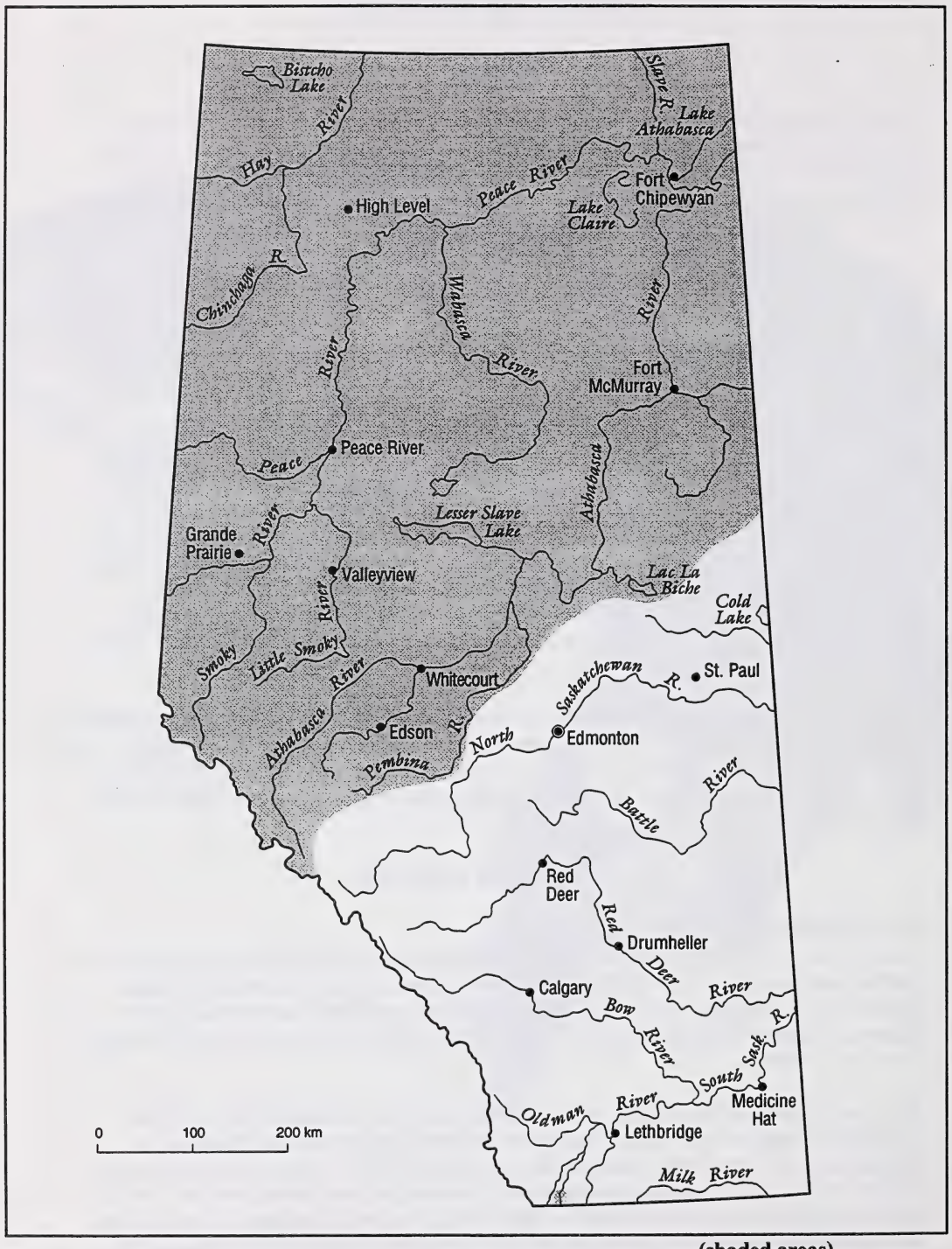

Figure 1: General Distribution of Arctic Grayling in Alberta (shaded areas)

1.2.2 Status

In Michigan, the extinction of grayling populations by the 1930s has been attributed to habitat alteration, pollution and overharvest. Grayling are native to Montana; however, hatchery plantings, including introductions from Canada, were required to re-estbalish some populations. The capture of an Arctic grayling from the Belly River in southern Alberta in 1995 indicates that a remnant population, originating from upstream in Montana, exists in the Belly River. Throughout Canada, Arctic grayling populations in accessible areas have declined because of the grayling's ease of capture and its sensitivity to habitat alteration.

Few detailed studies have been conducted on Arctic grayling populations in Alberta; however, considerable survey information has been collected about populations throughout the province (Appendix 1). At present, the general distribution for Arctic grayling throughout northern Alberta remains much the same as it was in the past, but within this range, some streams no longer support populations. The distribution of grayling has also been restricted within some streams to isolated populations in their headwaters. In general, the numbers and sizes of fish in all grayling populations have declined. These declines have resulted in a reduction in the health of populations. Although overharvest has contributed most to the declines, habitat alteration has caused fragmentation or loss of some populations.

The exact number of distinct Arctic grayling populations in Alberta is unknown; however, grayling occupying different watersheds represent different populations. Also, the current status of each population has not been fully documented. Arctic grayling, as a species, is not in danger of extinction, but individual populations continue to decline; therefore, the Fisheries Management Division has classified Arctic grayling in a "vulnerable status[1]." This is a term used to describe the status of a species of special concern in need of conservation measures to reverse long-term declines in their numbers.

Catch rates at healthy grayling populations range from 4-7 fish/hour; however, in many streams catch rates have declined to less than 1 fish/hour. A catch rate below 4-7 fish/hour is an indicator that fish production for the population is being limited by overharvest and habitat quality. Access to the entire Peace and Athabasca watersheds has been increased by oil and gas exploration and timber harvest development which is resulting in higher fishing pressure on grayling populations and impacts to grayling habitat.

A dominance of smaller-sized individuals has been a consistent pattern in Arctic grayling populations throughout Alberta, even from areas receiving light fishing pressure in the 1970s (Appendix 1). Mature grayling over 33 cm in total length, the approximate size of full maturity, make up a low percentage of most grayling populations (Figure 2 and Appendix 2). These mature fish are the most spectacular in colour and the overall fishing experience is diminished by their absence. A significant increase in fishing pressure has resulted in high harvest levels which have reduced population densities.

Although more remote areas such as the Caribou Mountains, Birch Mountains and Kakwa River basin still have grayling populations with good numbers of larger fish, most accessible areas have

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[1] - Refers to a sensitive species that is not currently believed to be at risk of extirpation within the province, but may require special management to address concerns related to naturally low populations, limited provincial distribution or demographic/life history features that make it vulnerable to human-related changes in the environment. Yellow List ('Not At Risk'); *The Status of Alberta Wildlife* (Wildlife Management Division 1996).

all but lost their populations. For example, the Pembina, McLeod and Wildhay watersheds had strong grayling populations prior to the 1950s, but only severely limited populations exist there today. Similar losses have occurred in the House River, Jackfish River, Christina River, Swan River, Smoky River and other streams.

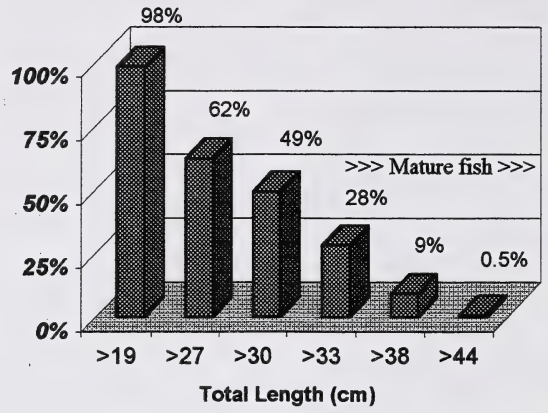

Figure 2. Cumulative percentages of Arctic grayling greater than given total lengths illustrating the low percentage of mature fish over 33 cm, the approximate size of full maturity (April and May samples, n = 3497).

1.3 Biology of Arctic Grayling

1.3.1 Habitat and Life-history Patterns

Although primarily stream dwellers, grayling are occasionally found in lakes. When found in lakes, grayling prefer the shallow areas along shore. Stream types for grayling range from those in the foothills to those throughout the boreal forests. In the foothills, grayling occupy the upper watersheds and extend downstream in the major drainages. Throughout the boreal forests, most of the streams containing grayling are low gradient, brown-water streams. These streams have moderate-to-high gradient sections that provide good grayling habitat, particularly for spawning and rearing. Streams with lakes in their headwaters offer more stable, year-round water flows than streams originating directly from muskeg areas. Grayling tend to avoid the turbid waters of large rivers by selecting locations where tributaries enter and by moving upstream into cleaner, cooler-water tributaries in the spring where they spend the summer.

Different life-history patterns exist for grayling populations because of the species' successful adaption to a wide variety of habitats and because habitat conditions in streams change with varying water flows and influences from beaver dams. The general pattern throughout their range is for grayling to move around using different streams and/or different stream locations to meet their habitat needs at various times of the year. Four variations on the general pattern are outlined below.

Watershed populations represent the most common pattern where major grayling movements occur within and among the streams of the watershed. These grayling primarily reside in the larger streams, but use many areas including tributaries. Mature grayling move considerable distances upstream in the spring to spawn in smaller tributaries, spend the summer feeding in the upper river systems, and move back downstream in the fall to overwinter in larger pools. Most of the adults return from the smaller tributaries to the larger stream shortly after spawning; however, the young remain in their natal (birth) tributaries for the first year and a half. This life-history pattern has been documented in the Little Smoky River watershed, in the Wapiti River, Beaverlodge River and Redwillow River watershed, and is thought to be a common pattern throughout the boreal forests.

Mainstem River populations closely resemble watershed populations, except that the mature grayling that overwinter in the large mainstem river spend most of the summer within tributary systems to avoid the turbid water conditions of the mainstem. The grayling leave the mainstem river during ice break-up at the end of April to enter tributaries. After spawning is complete, these grayling disperse and remain in the tributaries for the summer to feed. Immature grayling also move into these tributaries to feed during the summer. The majority of the grayling return to the mainstem river just prior to freeze-up during October and spend the winter. However, most of the young grayling remain in the tributaries for the first year and a half of their life. Although overwintering habitat is available for juvenile grayling, winter flows are generally insufficient to provide overwintering pools for adults. This life-history pattern has been document in the Athabasca River and its tributaries such as the Muskeg, MacKay, Steepbank and House rivers.

Stream Resident populations occur where grayling spend their entire lives in the same small stream. Beaver dams play an important role in providing overwintering areas for stream-resident grayling, although spring runoff is necessary to breach these dams to permit spawning movements. Grayling populations in the Assineau River, Marten River and Narrows Creek in the Lesser Slave Lake area are primarily stream resident. In areas such as the headwaters regions in the foothills, Caribou Mountains and Birch Mountains, beaver dams likely contribute to the existence of resident populations in some streams by restricting movements and isolating upper stream areas from lower stream areas where migratory populations occur.

Lake-dwelling populations occur in some lakes in Alberta. At Freeman Lake, grayling reside in the lake, but move into a tributary to spawn. Arctic grayling have also been reported in small lakes in the Caribou Mountains and Birch Mountains. Grayling have been stocked in a few small alpine lakes such as Bear Pond and Big Iron Lake. These populations survived for up to nine years before being lost to winterkill conditions. These lakes were restocked in 1997.

1.3.2 Spawning

Arctic grayling prefer small streams for spawning, although some grayling have been known to select areas within larger streams. The selection of a spawning stream can depend on water flow conditions providing access to particular streams. The same grayling have been documented spawning in different streams in different years in response to blockages caused by beaver dams during low water flows. Also, the selection of spawning areas within a stream can occur in headwaters areas during years of high discharge and in lower stream areas during years of low discharge. Access and use of smaller streams in headwaters areas provide an advantage because lower stream areas are more susceptible to floods and the subsequent loss of spawning success.

Arctic grayling generally select gravel or rocky bottoms in riffle areas in moderate-to-high gradient sections of streams. Sand and organic-material substrate along lake shores are sometimes used, but

evidence of lake spawning is not common. Studies in Alaska reported grayling spawning along the shore of a lake in one case and along the shore of a pond in a second case. In Alberta, shore spawning was documented in Big Iron Lake, prior to the winterkill of this stocked grayling population. Grayling stocked into MD Peace Pond have become self-sustaining because of successful spawning in a small spring-fed tributary. In the Caribou Mountains, lake populations of grayling spawn in outlet streams.

Spawning movements start immediately as the ice leaves the spawning streams at water temperatures of 0° C to 6° C. In most areas of Alberta, spawning occurs during the first two weeks of May, although at Freeman Lake and in foothill streams such as the Kakwa and Cutbank rivers, spawning occurs in late May. Males arrive on the spawning grounds before females. The dominant males select and defend spawning territories by chasing smaller males away or by swimming beside an intruding male in an aggressive, quivering display with raised dorsal fin and gaping mouth, until the intruder leaves. Females remain separate from males and only move into the territories of specific males to spawn. Most spawning occurs from noon to dusk, at water temperatures between 5° C and 10° C (range 2.2 °C to 16.7 °C).

Spawning involves the male curving his large dorsal fin over the female's back in a clasping fashion, and vigorous vibrations by the pair stimulate the release of eggs and milt. Although no egg nest (redd) is built, the fertilized eggs are forced down and become buried in the gravel loosened by the caudal fins during the spawning act. Females lay between 4000 and 7000 amber-coloured eggs measuring about 2.4 to 2.7 mm in diameter. Grayling eggs hatch in 11 to 22 days at water temperatures between 7° C and 11° C. Newly-hatched larvae are about 8 mm in length and spend 3 to 4 days in the gravel substrate absorbing their yolk before emerging as swimming fry.

1.3.3 Feeding Habits

The first food taken by grayling fry consists mainly of zooplankton (microscopic animals). Juveniles and adults are opportunistic feeders and eat a variety of food items from the stream bottom, mid-water and the surface. Aquatic insects (such as caddis flies, mayflies, stoneflies, dragonflies and midges) and terrestrial insects (such as bees, wasps, ants, grasshoppers and beetles) are very important to the diet of grayling. At times, snails, small fish, and even small mammals (such as mice, shrews and voles) are eaten by grayling. The schooling behaviour of grayling encourages competition and intensive feeding, and schools of grayling have been observed in feeding frenzies, repeatedly breaking the water's surface to grab floating insects. The grayling's tendency to feed heavily from the stream surface makes it easily caught on dry flies, but its behavioral traits also make it very willing to take most baits and lures.

1.3.4 Growth and Maturity

The Canadian angling record for Arctic grayling is 5 pounds and 15 ounces (2.7 kg), taken in 1967 from the Katseyedie River in the Northwest Territories. A tie at 2 pounds and 13 ounces (1.3 kg) currently exists for the Alberta record--one fish from the Embarras River (1966) and the other from the Smoky River (1987). The longest grayling recorded in Alberta surveys measured 51 cm in total length (Namur River 1967).

Most Arctic grayling populations throughout the province have very similar growth patterns as illustrated by length-at-age relationships (Figure 3 and Appendix 3). Growth is rapid in young grayling, which usually exceed 10 cm within the first year. Older grayling grow more slowly and usually require between five to seven years to reach lengths of 35 to 40 cm. Adult grayling suffer from particularly high natural mortality rates. As result, grayling are short lived, and few mature

age classes exist in most populations. With the exception of grayling aged 7 to 12 reported from the Kakwa River drainage in 1996, survey records for grayling populations throughout Alberta indicate few captures of fish over the age of 6 and only one over the age of 9 (Appendix 1).

Although some grayling can reach maturity at age 2, the majority do not become mature until age three or older. Generally in Alberta, about 50% to 70% of three year-old grayling have reached maturity and 100% of age four grayling are mature (age of full maturity). The size at full maturity (age 4) is approximately 33 cm in total length. A slower growth rate for grayling in the spawning migration at Freeman Lake suggests that a few populations in Alberta may take longer to grow to a spawning size.

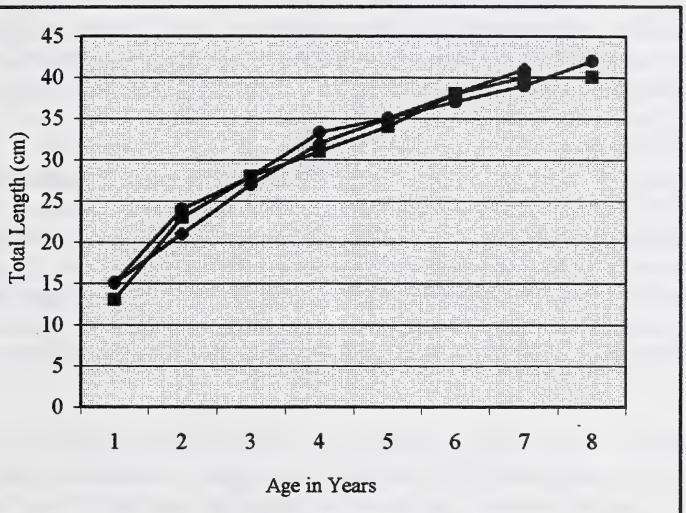

Figure 3. Length-at-age comparisons for Arctic grayling from three general areas in Alberta (Apr/May samples).

♦ Northeast Boreal Region (n= 1071)
■ North Eastern Slopes Region (n= 177)
● Northwest Boreal Region (n= 959)

1.4 Major Limitations to Production

A number of interelated factors affect the rate at which Arctic grayling can be produced. Major limitations to production include the following:

1. Productive Capacity of the Habitat

In many cases, the smaller tributary streams which Arctic grayling enter in the spring are limited in their amount of gravel riffles for spawning and pool areas for fish shelter. These nursery streams may also have a scarcity of space and cover for young, which limits the numbers of fish these streams can support. During low water cycles, flows may decline, leaving streams with only isolated small pools, or small streams may dry up completely. The need for adult grayling to move into pools in larger streams to ensure winter survival also limits production because pool sites can be limited in number and size. The rate of growth in individuals and the size of the population are also controlled by the amount of food the habitat can provide.

2. Habitat Alteration

Habitat alteration can result from oil, gas and mineral exploration and extraction, timber harvest, road and pipeline construction, road surfaces, ditches, side slopes, agriculture and cattle grazing, and industrial and recreational developments. Arctic grayling are very susceptible to various forms of habitat disturbances and are good indicators of the quality of aquatic environments.

Siltation, erosion and the removal of stream cover cause reduced productivity in streams because the following are lost: shelter, food production, and good spawning and nursery areas. Changes in watersheds that cause flash floods in the spring can render riffle areas unusable as spawning sites, can destroy eggs or can wash fry out of important nursery areas. Low stream flows during the spring can result in the blockage of spawning migrations because beaver dams are not opened up. The presences of heavy beaver damming in streams reduces spawning and rearing areas (riffle-pool-run habitat). Improperly installed culverts are also a major cause of spawning migration blockages. Low stream flows during the winter months can seriously impact survival of young grayling in nursery streams, and of adults when the number and size of pool areas are decreased.

3. Biological Constraints

Although grayling of all sizes frequently reside together in the same pool, dominant males tend to take up the best feeding locations at the expense of subdominant males and females. Because grayling are short lived, most of the limited number of mature fish that exist are required for conservation needs and few can be made available for harvest. Under some circumstances, such as the crowding of adults on a limited spawning area, the aggressive nature and territorial habits of dominant male grayling may affect reproduction sucess. In general, there is a need for numerous, visually isolated breeding territories to reduce conflict among males defending spawning territories.

4. Overharvest

Fish production is primarily controlled by the productive capacity of the habitat, the biological characteristics of the species and the species composition of the water body. However, fish harvest has historically been a major limiting factor on fish production. The aggressive feeding habits of grayling make them extremely easy for anglers to catch. The adults can be quickly removed until too few mature fish remain to provide sufficient spawning and subsequent recruitment to maintain the population. Current levels of harvest of Arctic grayling exceed the levels of fish that can be produced for this species in most areas of Alberta. In more accessible areas, overharvest has already contributed to population declines and the loss of grayling in some places.

2.0 MANAGEMENT PLAN

2.1 Management Policy

Alberta's Arctic Grayling Management and Recovery Plan is based on the mission statement, goals, objectives and guiding principles presented in the document *A Fish Conservation Strategy for Alberta* (Fisheries Management Division 1997). The mission statement for the Fisheries Management Division from that document is:

"To sustain the abundance, distribution and diversity of fish populations at the carrying capacity of their habitats."

Reduced fish production results from the alteration or loss of habitat and the overharvest of fish. Conservation of fish resources can not be achieved through control of fish harvest alone--habitat maintenance is essential. Conservation includes two components: 1) protection which ensures the perpetuation of abundant fish populations and 2) the appropriate use of only the surplus that is not required for population maintenance. Biodiverse and productive ecosystems maintain healthy fish populations and support social and economic benefits for Albertans.

In order for Albertans to enjoy the benefits that fish and fishing provide, there must be a sufficient fish resource available. Fish are a product of their habitat, and to produce fish there must be sufficient habitat available. The following are the goals of the mission statement:

- **HABITAT MAINTENANCE** --sustain, or achieve a net gain in, the quality and quantity of fish habitat; and

- **FISH CONSERVATION** --regulate fish harvest in line with, and not exceeding, the productive capacity of fish populations; and

- **FISH-USE ALLOCATION** --manage fish populations in a manner that meets the present needs of Albertans without compromising the ability of future generations to meet their needs.

Several guiding principles that help achieve the mission statement and goals are outlined in *A Fish Conservation Strategy for Alberta*. They are:

1. **No net loss of the productive capacity of habitats.**
   Every effort must be made to avoid habitat losses. If habitat losses are unavoidable, they should be balanced with habitat replacement.
2. **Fish populations are to be maintained by natural reproduction wherever possible.**
   Natural reproduction is the most biologically sound and cost-effective way of maintaining fish populations and fish production.
3. **The biological diversity of the fish fauna is to be maintained, and the depletion or extirpation of native fish species, populations, sub-populations or unique strains will not be permitted.**
   Any maintenance and protection strategy must include all fish species in order to maintain the biological diversity of the fish fauna.
4. **The management of fisheries will be based on fundamental ecological principles and factual information.**
   Good and timely information on fish (including their number, growth, production rate, harvest rate, habitat needs and habitat conditions) is fundamental to achieving habitat maintenance, fish conservation and fish-use allocation goals.

5. **There should be public involvement and education in the fisheries management process.**
   Greater public awareness and the involvement of a knowledgeable public are essential to increase public support for fisheries management.
6. **The "user-pays philosophy" should apply to the financing of the stewardship and management of fish resources.**
   The responsibility for financing the stewardship of fish resources must be shared by all, and supported directly by resource users such as anglers, resource developers and industries.
7. **Public access should be provided and maintained to waters producing publicly-owned fish.**
   Unencumbered access to waters producing publicly-owned fish is a prerequisite to using fish resources for public benefits.

2.2 Goals and Objectives

In line with the mission statement and guiding principles given above, the overall goal of Alberta's Arctic Grayling Management and Recovery Plan is:

> **"To sustain the abundance, distrbution and diversity of natural reproducing Arctic grayling populations and provide recreational and economic benefits to Albertans."**

2.2.1 Habitat Maintenance Goal

Restore and maintain the natural productive capacity of Arctic grayling habitat, and where possible and appropriate, increase the amount of productive Arctic grayling habitat.

Many aspects of habitat maintenance are not within the direct control of the Fisheries Management Division; therefore, the Fisheries Management Division must act as an advocate to have habitat maintenance integrated into the goals of natural resource users. Habitat protection, habitat mitigation and water quality need to be treated by all resource users as essential components of resource management planning. To achieve the habitat maintenance goal, water-use legislation and policy have to recognize fish as a user of water and incorporate the needs of fish into water resource management. Resource stewardship, although a mandate of government, is the responsibility of everyone--the general public and proponents of resource use.

In Alberta, the habitat program of the Fisheries Management Division uses the policy of no-net-loss of productive fish habitat as a working guideline for decision making *(Policy for the Management of Fish Habitat,* Fisheries and Oceans Canada 1986). Formal authority for the fish habitat provisions continues to reside with the Minister of Fisheries and Oceans. The objective of the federal policy is to achieve a net gain of habitat for fish resources. However, there are strict limitations on the potential to increase the productive capacity of habitats. Fish resources and fish habitats are finite and every effort to avoid habitat loss or damage must be made.

2.2.1.1 Habitat Maintenance Objectives

- Habitat Protection --maintain the productive capacity of aquatic habitats to support healthy and diverse Arctic grayling populations.
- Habitat Rehabilitation --alleviate or reverse adverse impacts on the productive capacity of habitats and repair damaged habitats.
- Habitat Development --enhance habitats in areas where the production of Arctic grayling populations can be increased, but maintain the aesthetic qualities of these sites.

2.2.2 Fish Conservation Goal

Restore and maintain the abundance, distribution and diversity of grayling populations through natural reproduction.

The Arctic grayling populations in Alberta have declined because of habitat losses and the overharvest of fish, to the extent that it is difficult to satisfy current demand and meet future needs. As a consequence, managing for conservation first is necessary. In this context, conservation focuses on sufficient protection to ensure abundant grayling populations and the appropriate use of only the surplus that is not required for population maintenance.

2.2.2.1 Fish Conservation Objectives

- Fish Production Maintenance --maintain the abundance and diversity of grayling populations at the carrying capacity of their habitat.
- Fish Production Restoration --restore diminished grayling populations to full production wherever possible.
- Fish Production Enhancement and Development --enhance or develop grayling production where appropriate and possible.

Beyond habitat conservation, the above objectives involve managing fish harvest by managing human activities through regulations, and by changing public attitudes through information and education.

2.2.3 Fish-Use Allocation Goal

Allocate the appropriate uses of Arctic grayling resources to achieve a range of optimal benefits that support the fish conservation goal.

Arctic grayling do not constitute a significant portion of harvest in the domestic fishery. Only a minor, accidental harvest may occur in cases where domestic fishing is allowed in northern streams such as in the Athabasca River delta. Commercial fisheries are not scheduled for Arctic grayling. Sportfishing is by far the largest user of the Arctic grayling resource in Alberta. Sportfishing is an ever-increasing activity which significantly impacts fish resources. The *Fish and Wildlife Policy for Alberta* (Fish and Wildlife Division 1982) promotes recreational fishing as a legitimate activity, in addition to promoting rules to regulate activities and encouraging the ethical conduct of anglers.

2.2.3.1 Fish-Use Allocation Objectives

Within the constraints of fish conservation:

- Sustain subsistence fishing for Alberta's aboriginal people where historical use of Arctic grayling occurred.
- Sustain a range of optimal recreational opportunities.

2.3 Management Strategies and Actions

2.3.1 Habitat Protection, Rehabilitation and Development Strategy

Habitat as used in the context of this strategy also includes instream flow needs, water quality, fish health and ecosystem integrity. Habitat disturbances result from oil, gas and mineral exploration

and extraction, timber harvest, road and pipeline construction, road surfaces, ditches, side slopes, agriculture and cattle grazing, and industrial and recreational developments. A policy of no-net-loss of productive fish habitat will be used as a guideline. Where mitigative procedures can not eliminate habitat losses, then fish habitat compensation is necessary.

The habitat protection strategy involves:

- Identifying and protecting critical habitat for all life stages of grayling, but most particularly spawning and rearing.
- Identifying important grayling migration routes and maintaining these routes free of blockages, such as beaver dams and poorly installed culverts, to avoid population fragmentation, which can lead to population extinction.
- Restricting or limiting instream work, and the diversion or removal of water to appropriate time periods and activities that can be fully mitigated.
- Implementing habitat enhancement projects to improve spawning and rearing areas, and fish access to them, and to improve stream bank cover and stability.
- Identifying and maintaining adequate habitat protection guidelines to minimize, ideally to zero, any impacts from physical disturbances of streambank vegetation or within watersheds that affect water flow, water temperature, stream sedimentation, nutrient loading and contaminant levels in fish.
- Requiring proponents of development (natural resource, industrial and recreational) to rehabilitate the habitat they alter to restore productive capacity.
- Requiring the proponents of watershed disturbances, including instream work, to determine the extent and type of fish use and habitat base of affected streams prior to disturbance, incorporate appropriate habitat protection and compensation measures into development plans, monitor results of compensation actions and maintain habitat compensation features.
- Advocating habitat maintenance and fish conservation, and working with proponents of resource development to integrate fish habitat needs into their resource management planning.
- Advocating water-use legislation and policies that recognize fish as a user of water and the incorporation of the needs of fish into water resource management.

2.3.2 Fish Production, Restoration and Enhancement Strategy

Each water body has a limit to the biomass or total weight of fish that it can produce (productive capacity). This biomass can consist of many small fish, a few large fish, or a mixture of fish sizes. A broad range of fish sizes, consisting of many year-classes, is best and there must be a sufficient number of mature fish to support spawning and subsequent recruitment. Fish harvest has to be regulated to match and not exceed the productive capacity of the habitat. Restoring fish production must rely on habitat maintenance, habitat enhancement and harvest regulation rather than fish stocking. Natural reproduction is the best way to increase populations.

The fish production strategy involves:

- Maintaining a wide distribution of healthy grayling populations by ensuring that each population, within its natural limitations, is protected from further decline and managed for sustained production to:
  -increase the numbers of grayling in populations through natural reproduction, and
  -increase the spawning potential in populations by increasing the size and age of grayling through regulation of harvest to ensure more grayling survive to the age of full maturity plus one year (age 5 at about 35 cm total length).
- Minimizing impacts on grayling populations from increased public access to remote areas by:
  -placing restrictive regulation on grayling harvest, and

-encouraging the maintenance of wilderness and heritage values where appropriate through controlled access.

- Encouraging cooperative strategies with neighbouring jurisdictions[2] for Arctic grayling management by:
  -creating opportunities to conduct joint studies, and
  -sharing information.
- Developing specific operational plans from this provincial management and recovery plan, so that each watershed is covered--providing site-specific status of populations (high, medium or low risk of extirpation and areas in need of additional study).

2.3.2.1 Arctic Grayling Stocking

Stocking or transfers of Arctic grayling are guided by the documents *A Decision-Making Process for the Evaluation of Fish Introductions in Alberta* (Berry and Stenton 1993) and *Fish Stocking Process for Alberta* (Fisheries Management Division 1995). **Fish Production based on natural reproduction has priority over stocking, but where approved, stocking waters with Arctic grayling must meet policies pertaining to the protection of sensitive species and ecosystems, and the maintenance of genetic integrity of natural grayling populations.**

Arctic grayling stocking programs will be limited in size and will be guided by the following:

- Grayling stocking may be considered to develop new populations in small, preferably land-locked lakes, that are devoid of wild game fish populations and intended as catch-and-release fisheries (at least for the first five years). Within the grayling's native range, grayling stocking may be used to replace rainbow trout stocking where there are concerns about the continued use of stocked rainbows within the native range for the "Athabasca rainbow trout."
- Grayling stocking or transfers may be considered to re-establish lost or collapsed populations using genetically compatible stains.

2.3.3 Fish-Use Allocation Strategy

- Meet the traditional subsistence fishing needs of Alberta's aboriginal people and encourage the use of species which are more plentiful than Arctic grayling.
- Sustain a variety of recreational opportunities to meet the expectations of Alberta anglers within the constraints of fish conservation by:
  - sustaining quality fisheries, wilderness experiences and heritage values through catch-and-release fishing (0-limits),
  - providing access to harvest with strict limits on harvest,
  - distributing harvest among more anglers over a longer time period through protective regulation (0 limits or season closures) when grayling are most vulnerable (fall, winter and spring),
  - ensuring low mortality of released fish, and
  - discouraging the use of Arctic grayling for tournament and derby fishing.
- Encourage development of fish viewing opportunities involving Arctic grayling.

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[2] - Arctic grayling also occur in the adjacent jurisdictions of British Columbia, Saskatchewan, Northwest Territories, and Wood Buffalo and Jasper National Parks. The majority of the streams which cross jurisdictional boundaries are small headwaters streams; however, a few shared, migratory populations undoubtedly exist in mainstem rivers.

2.3.4 Public Involvement, and Information and Education Strategy

Public involvement in fisheries management is growing quickly. Volunteers have assisted with many habitat development and restoration projects. Volunteer programs often provide excellent opportunities for educating the public. Project funding from the Alberta Conservation Association's Fisheries Habitat Development and Fisheries Management Enhancement programs has provided many volunteer opportunities other than those provided by government programs. There is considerable enthusiasm among anglers, particularly members of sportfishing organizations, for participating in this type of activity and it is becoming an important part of their overall recreational experience.

Greater public awareness is essential to increase support for the management and recovery of Arctic grayling. Any attempt to regulate the harvest of grayling will be ineffective without the successful education of the public and the general acceptance of regulations.

The public involvement and information and education strategy involves:

- Working with industry, other stakeholders and various levels of government to develop a greater appreciation for the importance of habitat protection.
- Communicating to the public, industry and various levels of governments the habitat needs and biological requirements for Arctic grayling conservation.
- Including non-government organizations as participants in public information and education programs.
- Encouraging public involvement in:
  - -advocating the priority of fish conservation needs over other uses,
  - -conducting habitat enhancement projects to improve spawning and rearing areas, to remove or reduce the impacts of stream blockages, to improve stream bank cover and stability, and to maintain natural water flows,
  - -developing guidelines and identifying of streams that have special values and characteristics that should be retained to ensure the quality of the wilderness experience and preservation of "heritage" values,
  - -acting as an advocate of habitat maintenance and encouraging the incorporation of fish habitat needs into resource development planning and water management, and
  - -participating in the Alberta Conservation Association's REPORT-A-POACHER program to report suspected resource violations.
- Encouraging industrial developers and other natural resource users to provide funding for research and impact-assessment.

2.3.5 Enforcement Strategy

It is difficult to achieve angler compliance with fishing regulations through enforcement, without first achieving public acceptance of the management plan through public education. A well-informed public will increase angler compliance and assist enforcement efforts. The enforcement strategy involves:

- Setting priorities on district enforcement needs for public information and education, protection of critical grayling habitat and regulation enforcement.
- Developing district programs that improve compliance with grayling regulations through education, prevention and enforcement.
- Enforcing regulations that protect critical habitat.
- Encouraging courts to levy higher fines for serious offenses.

2.4 Inventory, Monitoring and Research Needs

The long-term success of Alberta's Arctic Grayling Management and Recovery Plan depends on the availability of good and timely information which is fundamental to achieving the habitat maintenance, fish conservation and fish-use allocation goals. Financial support for the management of fish resources and habitats on behalf of Albertans has to come from government through general revenue. The government is responsible for conserving these resources for all Albertans and for future generations. However, government financing should be augmented by fees and levies on direct resource users such as anglers, and on indirect resource users such as industries that alter habitat. The Alberta Conservation Association can play an important role by assisting with the financing of Arctic grayling studies. Additional opportunities should be investigated, such as funding from industries that impact fish resources, to study problems and to research methods that reduce impacts. Inventory, monitoring and research is required for:

- Gathering relevant information on fish stocks including their number, growth, production rate, harvest rate, and to determine the status of populations.
- Gathering relevant information to assess the effectiveness of regulations, and habitat protection, rehabilitation and enhancement.
- Gathering relevant information on fish habitat conditions and identifying and recording the location of critical grayling habitat and migration routes requiring protection, rehabilitation or enhancement.
- Conducting specific studies of life history, including movements and critical habitat requirements.
- Conducting studies to identify relationships between beavers and grayling habitat quality, and investigating beaver management solutions.
- Determining the carrying capacity of various habitats for Arctic grayling, the conservation needs to perpetuate grayling populations and the numbers that constitute a harvestable surplus.
- Conducting studies to understand the interaction between land-use impacts and natural events that limit or enhance grayling populations.
- Investigating the use of gear restrictions such as bait bans, barbed hook bans and treble hook bans, for their potential to reduce hooking mortality.

2.5 Sportfishing Regulations Development[3]

Arctic grayling populations in the Northern East Slopes, Northwest Boreal and Northeast Boreal regions have similar patterns of growth, age-class distributions, age and size at maturity, catch rates and vulnerable status. Therefore, a single approach to the regulation of sportfishing for Arctic grayling can be applied throughout the species range in Alberta[4].

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[3] - Alberta's Arctic Grayling Management and Recovery Plan is neither a legal document nor a complete listing of current sportfishing regulations. Details can be obtained from the nearest Natural Resources Service office.

[4] - Sportfishing regulations under the Alberta Fishery Regulations do not apply to waters within National Parks or other provinces and territories.

2.5.1 Sportfishing Seasons

As of 1998, the winter and spring sportfishing seasons will be closed. The general season during which anglers are allowed to catch and keep Arctic grayling will be restricted to the summer period, followed by catch-and-release fishing during a portion of the fall.

The general season dates for various watersheds are as follows:

A. For the Athabasca and Pembina river watersheds located in the Northern East Slopes Region:
   - Season closure from November 1 to June 15*,
   - Harvest permitted from June 16 to August 31, and
   - 0 limit from September 1 to October 31.

B. For all other watersheds in the Northern East Slopes, Northwest Boreal and Northeast Boreal regions:
   - Season closure from November 1 to May 31,
   - Harvest permitted from June 1 to August 31, and
   - 0 limit from September 1 to October 31.

* - The season closure extends to June 15 to provide spring spawning protection for native rainbow trout populations.

The season closure from November 1 to May 31 and/or June 15, provides protection to grayling congregated in overwintering pools, and in the spring to reduce disturbance during spawning. The zero limit between September 1 and October 31, when grayling are most vulnerable to harvest, will achieve the following:
- sustain the spawning potential of populations for the following spring,
- redistribute harvest to more anglers during the following summer, and
- continue to provided recreational opportunities the during the fall.

Harvest of adult grayling in the fall can seriously deplete the spawning potential of populations for the following spring. Good growth of grayling over the summer was observed during a study of the Arctic grayling in the Steepbank River, a lightly exploited population in 1977. Figure 4 illustrates the high percentage of large, mature grayling during the fall which are very vulnerable to harvest when moving downstream to wintering areas.

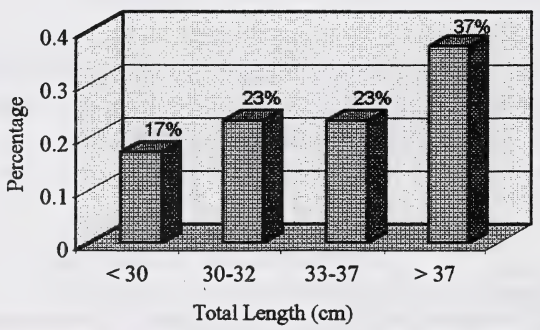

Figure 4. Size composition of Arctic grayling from fall samples (Sept/Oct n= 1072) from the Steepbank River, 1977 (data from Machniak and Bond 1979).

2.5.2 Minimum-size Limit

As of 1998, the new minimum-size limit for Arctic grayling will be 35 cm total length.

Minimum-size limits protect small fish from harvest allowing more to survive to spawning size. In the past, the size limit selected was intended to protect fish until they had spawned at least once. However, the minimum-size limit of 30 cm total length in effect between 1987 and 1998 failed to protect grayling populations. Too many fish were harvested before they had the chance to spawn because the size at full maturity for grayling is close to 33 cm in total length at about age 4.

Under current strategies, the target is to protect grayling to the age of full maturity plus one year (age 4 + 1 = age 5). On average, age five grayling are 35 cm in total length (Figure 5). This strategy will protect at least three mature age classes (ages 3, 4 and 5) prior to grayling reaching the size for legal harvest and benefit from additional spawning by ages 6 and older.

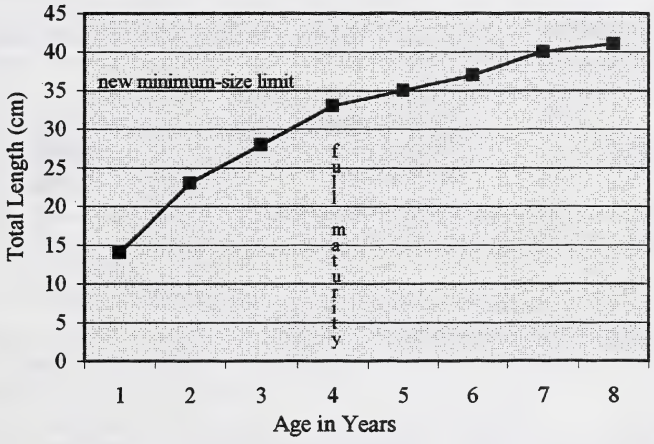

Figure 5. Length-at-age for Arctic grayling in Alberta (April/May samples from 18 studies in the Northern East Slopes, Northeast Boreal and Northwest Boreal regions, n= 2207).

2.5.3 Daily Catch Limit

As of 1998, the daily catch limit for Arctic grayling will be two (Arctic grayling and trout combined limit is 2). Also, zero limits (catch-and-release fisheries) will be established at site-specific streams.

The daily catch limit of 5 grayling between 1970 and 1998 failed to protect populations from overharvest. By contrast, the zero-limit fishery established in 1989 on the upper portion of the Little Smoky River has sustained a quality fishery, occasionally reaching a catch rate of 8-10 fish/hour. A decrease in the daily catch limit from 5 to 2 will reduce harvest and will help distribute the available harvest more fairly among anglers. Coupled with the larger minimum-size limit of 35 cm, the reduced daily limit will result in the availability of more spawners and will subsequently result in an increase in the production of young fish.

Arctic grayling are short lived because adults suffer from high natural mortality rates. Therefore, allowing some harvest of the larger, older grayling where appropriate represents a harvest by anglers of some grayling that may otherwise have been lost to natural mortality.

2.5.3.1 Catch-and-Release Fisheries (0-limits)

Zero-limit fisheries (catch-and-release) will be established at various streams to:

- permit faster recovery of collapsed populations,
- sustain unique recreational opportunities through the provision of quality fisheries and quality fishing experiences, and
- ensure the quality of the wilderness experience and preservation of heritage river systems.

Several streams have been designated as catch-and-release fisheries as a result of recommendations from the Eastern Slopes Regulations Review Steering Committee. A few additional streams will be classified as catch-and-release fisheries as part of furture regional plans for Arctic grayling management in the Northeast and Northwest Boreal regions after the required studies and public consultations have been completed.

The following streams, or portions of these streams, have been established as catch-and-release fisheries for Arctic grayling (see the most recent copy of the Alberta Guide to Sportfishing Regulations for up-to-date information):

Belly River	Freeman River	Rat Creek
Deep Valley Creek	Gregg River	Wildhay River
Dismal Creek	Kakwa River	Windfall Creek
Embarras River	Little Smoky River	

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Appendix 1. Age-length relationships of Arctic grayling from various Alberta locations.

Location Drainage System		Sample Period	Mean Fork Length (mm) at Age 0	1	2	3	4	5	6	7	8	9
Muskeg River Lower Athabasca	a	Apr/May 76 n= 103		160 18	216 27	251 37	310 17	323 2		372 2		
Steepbank River Lower Athabasca	b	Apr/May 77 n= 191		158 1	206 85	258 18	298 48	331 27	353 10	368 2		
MacKay River Lower Athabasca	c	Apr/May 78 n= 29			200 7	237 9	277 2	307 6	341 3	378 2		
Hartley Creek Muskeg/Athabasca	d	May 81 n=217			175 58	223 52	269 55	324 33	349 19	373 4		
House River Lower Athabasca	e	May 95 n=527		94 24	172 229	254 208	305 41	317 21	331 4			
Namur River Ells/Athabasca	f	Aug 67 n= 42		195 2	255 7	331 7	359 18	371 8				
High Hill River Clearwater/Athabasca	f	Sept 72 n= 59		176 1	206 4	239 12	276 27	293 12	326 3			
Ells River Lower Athabasca	f	Sept 72 n= 15	106 1	175 2	228 5	269 4	268 3					
Dismal Creek Pembina/ Athabasca	g	Apr/May 81 n= 60		90 2	181 8	213 3	254 15	276 23	318 6	348 3		
Rat Creek Pembina/Athabasca	h	May/June 92 n= 6 July/Aug 91 n= 28 Sept 91 n= 12	 86 14 114 7	168 4 194 12 206 5	243 2 285 1	 335 1						
Lovett River Pembina/Athabasca	i	July/Aug 74/75 n= 28	57 7	90 9	160 10	220 2						
Cold Creek Pembina/Athabasaca	j	May 1950 n= 207		111 13	171 15	226 54	267 75	294 32	317 16	326 2		
Sundance Creek McLeod/Athabasca	k l	May 92 n= 40 July 91 n= 115 Oct 91 n= 71 Apr/May 93 n = 43 July 93 n= 37	 68 93 100 63 71 12	122 33 165 12 191 4 105 13 166 19	214 6 234 2 268 4 200 22 218 6	269 1 295 8 277 2	 302 5	 355 1				
McLeod R. Tributaries McLeod/Athabasaca	m	June 1947 n= 47			201 14	226 24	274 8	301 1				
Wildhay River Berland/Athabasaca	h	Sept 91 n= 24			167 1	196 5	238 6	263 11		302 1		

Appendix 1. Continued.

Location Drainage System		Sample Period	Mean Fork Length (mm) at Age 0	1	2	3	4	5	6	7	8	9
Freeman Lake Inlet Freeman/Athabasca	n	May/June 86 n= 28					292 2	313 2	371 5	386 18	365 1	
Swan Hills Streams Swan/Lesser Slave L.	o	May/June 73 n= 50		128 5	210 18	234 17	260 8	295 1	318 1			
Swan River Lesser Slave L/Atha.	p	July/Aug 78 n= 10				273 2	319 2	355 1	377 3			
Little Smoky River Smoky/Peace	q	July 88 n= 195 Calculated length at annuli (scales)		174 34 147	229 44 221	265 72 270	292 35 302	326 10 335				
Bird/South Lake creeks L.Smoky/Smoky/Peace	r	June/July 88 n= 26		111 5	153 6	219 12	251 3					
Waskahigan river L.Smoky/Smoky/Peace	t	June 83 n= 41		116 4	162 12	215 11	229 4	268 5	262 3	296 1	333 1	
Beaverlodge River Wapiti/Smoky/Peace	u u t t	May 82 n= 49 May 83 n= 67 Apr 85 n= 287 May 86 n= 273			150 1	253 49 269 23 298 1	313 2 277 5 299 184 283 34	320 12 358 4 330 61 298 123	332 25 347 6 362 17 303 94	335 10 354 2 341 2 326 18	 355 3	
Redwillow River Wapiti/Smoky/Peace	v	May 84 n= 25				188 2	277 7	288 7	300 8		347 1	
Pinto Creek Wapiti/Smoky/Peace	t	1985 n= 33		92 1		191 4	223 12	265 9	315 5		350 1	
Wapiti River Smoky/Peace	w	1984 n= 11				245 1	292 2	282 4	322 3	330 1		
Deep Valley Creek Simonette/Smoky/Peace	t	May/June/July 83 n= 31			154 4	211 3	265 6	303 4	324 9	328 3	360 1	370 1
Kakwa River Smoky/Peace	t	1983 n= 31		155 6	208 4	224 5	267 7	301 5	322 2	321 2		
Cutbank River Smoky/Peace	t	May/June 85 n= 31				240 1	226 15	242 5	259 6	324 4		
Heart River Peace	t	1972 n= 7			235 2	264 3	333 2					
Cadotte/Otter Rivers Peace	x	Apr 78 n= 74			211 3	277 4	313 8	329 38	350 14	379 6	392 1	

Appendix 1. Concluded.

Location Drainage System		Sample Period	Mean Fork Length (mm) at Age 0	1	2	3	4	5	6	7	8	9
Loon R. Tributaries Wabasca/Peace	t	June 76 n= 40		110 5	153 19	194 9	250 7					
Mikkwa River Lower Peace	t	May 68 n= 60		139 15	222 32	284 13						
Lawrence River Lower Peace	t	June 68 n= 32		177 3	119 1	314 1	357 14	386 5	418 8			
Wentzel River Lower Peace	t	Sept 70 n= 47		146 10	228 5	265 19	304 7	332 1	367 4	383 1		
Dizzy Creek Hay	t	June 68 n= 59			191 10	240 23	274 11	314 12	350 1	357 2		

			Mean Fork Length (mm) at Age 3	4	5	6	7	8	9	10	11	12
Prairie Creek Kakwa/Smoky/Peace	y	July/Aug 96 n= 34	198 2	249 3	260 7	291 3	267 10	271 2	315 2	283 2	293 1	355 2

a- Bond and Mackniak (1979) .
b- Machniak and Bond (1979).
c- Machniak et al (1980).
d- R. L. &L. (1981).
e- R. L. &L. (1995).
f- Griffiths (1973).
g- R. L. &L. (1981b).
h- R. L. &L. (1993).
i- R.L.&L. (1988).
j- Ward (1950).
k- R. L. &L. (1993b).
l- R. L. &L. (1995b).
m- Millar (1947).
n- Hawryluk (1987).
o- Bishop (1980).
p- Berry (1978).
q- Sterling and Hunt (1989).
r- Sterling (1987a & b).
s- Brilling (1985)
t- Peace River Office Files.
u- Schroeder et al (1983)
v- Lucko (1984)
w- Lucko (1985)
x- Walty (1980)
y- Kakwa River studies (ongoing)

Appendix 2. Proportion of Arctic grayling larger than given lengths (total length).

Study Location	Sample Period	Capture Method	Sample Size	Cumulative number of fish larger than: 19 cm	27 cm	30 cm	33 cm	38 cm	44 cm
Athabasca R.									
Muskeg R.	May 76	Trap	110	95	49	40	16	4	0
Muskeg R.	May 77	Trap	149	149	90	68	46	25	0
Steepbank R.	Apr/May 77	Trap	1447	1444	816	582	247	133	0
Hartley Cr.	May 81	Trap	903	849	335	199	104	63	0
House R.	May 95	Trap	37	35	35	28	17	7	0
Sub-total			2646	2572	1325	917	430	232	0
(percent)				(97)	(50)	(35)	(16)	(9)	(0)
Wapiti R.									
Redwillow R.	May 84	Trap	25	25	23	20	11	2	0
	May 93	Trap	88	88	88	86	57	13	0
Beaverlodge R.	Apr 85	Trap	288	288	285	272	185	31	2
	May 86	Trap	292	292	290	278	144	11	2
	May 87	Trap	158	158	158	158	136	12	0
Sub-total			851	851	844	814	533	69	4
(percent)				(100)	(99)	(96)	(63)	(8)	(<1)
Combined Total			3497	3423	2169	1731	963	301	4
(percent)				(98)	(62)	(49)	(28)	(9)	(<1)
Spring & Fall									
Steepbank R.	Apr/May 77	Trap	1447	1444	816	582	247	133	0
(percent)				(100)	(56)	(40)	(17)	(9)	(0)
Steepbank R.	Oct 77	Trap	1072	1071	974	891	641	395	0
(percent)				(100)	(91)	(83)	(60)	(37)	(0)
Kakwa R.									
Copton/Lynx creeks	Aug 95	Trap	127	127	83	71	27	2	0
Prairie Creek	Aug 96	Angling	181	181	109	80	32	6	0
Combined			308	308	192	151	59	8	0
(percent)				(100)	(62)	(49)	(19)	(3)	(0)

Appendix 3. Age-length relationships of Arctic grayling from different regions of Alberta from spring and fall samples.

Region	Sample Period	Mean Fork Length (mm) at Age 0	1	2	3	4	5	6	7	8	9
N.E. Boreal	Apr/May n= 1071 studies= 5		137 43	194 406	245 324	292 163	320 89	344 36	373 10		
N.E. Slopes	Apr/May n= 177 studies= 4		121 52	210 38	253 6	283 22	315 26	345 11	367 21	365 1	
N.W. Boreal	May n= 959 studies= 9		139 21	216 107	255 76	304 265	320 300	339 152	354 33	380 5	
Combined	Fork length (mm) Total length (cm) n= 2207 studies= 18		130 14 116	207 23 551	251 28 406	296 33 450	319 35 415	341 37 199	363 40 64	376 41 6	
N.E. Boreal	Aug/Sept n= 116 studies= 3	106 1	182 5	230 16	280 23	301 48	332 20	326 3			
N.W. Boreal	Sept n= 47 studies= 1		146 10	228 5	265 19	304	332 7	367 4	383 1		
Combined	Fork length (mm) Total length (cm) n= 163 studies= 4	106 12 1	173 19 15	229 25 21	276 30 42	302 33 55	332 36 21	347 38 7	383 42 1		

Kakwa River drainage	July/Aug 96	Mean Fork Length (mm) at Age 3	4	5	6	7	8	9	10	11	12
Prairie Creek	Fork length (mm) Total length (cm) n= 34	198 22 2	249 27 3	260 29 7	291 32 3	267 29 10	271 30 2	315 34 2	283 31 2	293 32 1	355 39 2